Chromosome records for four species of *Pellaea* section *Platyloma* (J.Sm.) Hook. & Baker (Adiantaceae) from Australia

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Summary

Kokubugata, G., Bostock, P.D. & Forster, P.I. (2006). Chromosome records for four species of *Pellaea* section *Platyloma* (J.Sm.) Hook. & Baker (Adiantaceae) from Australia. *Austrobaileya* 7(2): 341–345. Somatic chromosomes (2n) from nine populations of all four currently recognised Australian *Pellaea* species, *P. falcata*, *P. nana*, *P. paradoxa* and *P. calidirupium*, were observed by the standard aceto-orcein staining method. *Pellaea falcata*, *P. nana* and *P. paradoxa* respectively showed a chromosome number of $2n = 58$ (2x; x = 29). One of two populations of *P. calidirupium* showed a chromosome number of $2n = 87$ (3x) with the other showing $2n = 116$ (4x). The diploid counts obtained for *P. falcata* and the triploid result for *P. calidirupium* differ from previously published reports, which were based on New Zealand collections.

Key Words: *Pellaea calidirupium, Pellaea falcata, Pellaea nana, Pellaea paradoxa*, chromosomes, polyploidy, Australian flora, New Zealand flora

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Introduction

Pellaea Link is a genus of at least 35 species with the majority in the southwestern United States and Mexico, but with scattered taxa also occurring in South America, Africa, India, Malesia, Australia and the western Pacific (Tryon *et al.* 1990). Four sections have been recognized, *viz.* sect. *Pellaea* with *c.* 16 species in America and one in Africa, sect. *Ormopteris* (J.Sm.) R.M. & A.F.Tryon with six species in South America, sect. *Holcochlaena* Hook. & Baker with ten species from Africa to India and Sri Lanka, and sect. *Platyloma* (J.Sm.) Hook. & Baker, presently with five species, from India and Sri Lanka to Australia, New Zealand and New Caledonia (Tryon 1990; Bostock 1998).

Pellaea sect. *Platyloma* presents some difficulties taxonomically. Until recently this section comprised only three species, *P. falcata*, *P. paradoxa* and *P. rotundifolia*, the last endemic to New Zealand. Field surveys and laboratory analysis (Brownsey & Lovis 1990; Garrett 1992, 1995; Bostock 1998) have resulted in the publication of a new species, initially considered a New Zealand endemic but later accepted for Australia (*P. calidirupium*), the raising of a variety to specific status (*P. falcata* var. *nana* to *P. nana*) and speculation as to whether further 'cryptic' species might be present (Bostock 1998).

Two haploid chromosome numbers have been determined in the genus, n = 29 (Britton 1953; Brownlie 1954, 1957; Knobloch & Britton 1963; Lovis 1977; Tryon & Tryon 1982; Benham & Schaack 1988; Brownsey & Lovis 1990; Gastony 1990; Lin *et al.* 1990; Tryon *et al.* 1990; Bostock 1998; Tindale & Roy 2002) and n = 30 (Manton & Sledge 1954; Kato *et al.* 1992; Manickam & Irudayaraj 1998). In Australia and New Zealand, thus far, counts of n = 29 (2x), n = 31 (2x + 2) and 58 (4x) at meiotic metaphase I have been recorded for taxa in sect. *Platyloma* (Brownlie 1954, 1957; Brownsey & Lovis 1990; Bostock 1998; Tindale & Roy 2002). Apomixis has been noted in the genus (Tryon & Britton 1958; Tryon 1968, 1972) but has not yet been proven for sect. *Platyloma*. Some forms of *Pellaea* recorded from Australia are strongly suggestive of hybrid origin but again this has not been proven (Bostock pers. obs.). Regardless of taxonomic problems,

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cytotaxonomic determinations of species in sect. *Platyloma* are few in Australia and although taxa distributed in New South Wales and Queensland were included by Tindale & Roy (2002), populations found in the latter have been poorly investigated.

The present study aims to investigate the somatic chromosomes of Australian *Pellaea* species as a contribution to cytotaxonomic knowledge of the genus, and to compare chromosome numbers of *P. calidirupium* and *P. falcata* from Australian populations with those reported for the same taxon from New Zealand localities.

Materials and methods

The taxonomic treatment of *Pellaea* in the present study follows Bostock (1998). Nine populations of the four species of *Pellaea* currently recognised in Australia were used as materials in the present study (**Table 1**, **Fig. 1**). Voucher specimens are deposited in the Queensland Herbarium (BRI).

Root tips were collected and pretreated in 2 mM 8-hydroxi-quinoline at 20° for 4 hours after which they were fixed in acetic ethanol (1:3) at 4° for at least 2 hours. Fixed root tips were macerated in a mixture of 1N hydrochloride and 45% acetic acid at 60° for 15 seconds and stained in 2% aceto-orcein on slide glasses at 20° for 6 hours. After being squashed with 45 % acetic acid, the chromosome numbers at mitotic metaphase ($2n$) were counted for each population.

Results and discussion

(1) *Pellaea falcata* (R.Br.) Fée

The three populations of *Pellaea falcata* investigated showed a chromosome number of $2n = 58$ (2x; x = 29) at mitotic metaphase (**Fig. 1A–C**). The diploid counts recorded in this study agree with those of Tindale & Roy (2002) based on accessions collected from two localities in New South Wales. Previously, Brownlie (1961) and Brownsey & Lovis (1990) reported that a New Zealand population of *P. falcata* showed $n = 58$ at meiotic metaphase I, and was therefore tetraploid (4x). Based on the available cytological data for this species, there appears to be at least two polyploid series (2x and 4x) in *P. falcata*, with the tetraploids occurring in New Zealand and the diploids in Australia.

(2) *Pellaea nana* (Hook.) Bostock

The populations of *P. nana* investigated both had a chromosome number of $2n = 58$ (2x) at mitotic metaphase (**Fig. 1D & E**). A tetraploid cytotype (4x) distributed in northeast Queensland (Tindale & Roy 2002) and an aneuploid cytotype (2x + 1), which is considered as being of hybid origin in Queensland (I. Manton in Tindale, 1972), were previously reported for this species.

This species was recently raised from a variety of *P. falcata* to specific rank and is considered an endemic Australian species. It is morphologically closest to *P. falcata* (Bostock 1998). In the present study, there is not enough data to reveal the cytotaxonomic relationship of the two species, but it is quite plain that they not only share morphological similarities but also diploid and tetraploid cytotypes.

(3) *Pellaea paradoxa* (P.Br.) Hook.

The two populations of *P. paradoxa* investigated showed a chromosome number of $2n = 58$ (2x) at mitotic metaphase (**Fig. 1F & G**). The chromosome numbers counted in the present study was consistent with Bostock (1998) reporting a diploid cytotype ($n = 29$; 2x) for Queensland material, and Tindale & Roy (2002) reporting a diploid cytotype ($2n = 58$; 2x) for material collected in New South Wales. Moreover, Tindale & Roy (2002) also reported a tetraploid cytotype ($2n = 116$) from New South Wales material. The present study shows that *P. paradoxa* has multiple polyploid cytotypes (two at least), similar to the other three *Pellaea* species investigated here.

(4) *Pellaea calidirupium* Brownsey & Lovis

Two Australian populations of *P. calidirupium* were examined in the present investigation. One population showed a chromosome number of $2n = 116$ (4x; **Fig. 1H**) and the other showed $2n = 87$ (3x; **Fig. 1I**). The chromosome number of $2n = 116$ (4x) of the former agrees with that of the tetraploid cytotype ($n = 58$) in New Zealand reported by Brownsey & Lovis (1990). On the other hand, the triploid count

Table 1. Chromosome counts for four species of *Pellaea* species together with the localities of collection and voucher details (NSW = New South Wales; Qld = Queensland)

Species	Voucher	Location	2*n*
P. falcata	*P.D.Bostock 358*	Hell Hole Creek, *c.* 34 km ENE of Warwick, Qld	58
	J.Bruhl s.n.	cultivated Armidale, ex Gosford, NSW	58
	P.D.Bostock 2005 & G.Kokubugata	Broken Head, NSW	58
P. nana	*P.D.Bostock 794A et al.*	Swan Creek, *c.* 29 km ENE of Warwick, Qld	58
	P.D.Bostock 2001 & G.Kokubugata	Mt. Maroon, 25 km SSE of Boonah, Qld	58
P. paradoxa	*P.D.Bostock 2002 & G.Kokubugata*	East Kipper Creek, 16 km WSW of Esk, Qld	58
	P.D.Bostock 2004 & G.Kokubugata	Mt. Tamborine, *c.* 55 km SSE of Brisbane, Qld	58
P. calidirupium	*P.I.Forster PIF11602 et al.*	Wilgavale near Texas, Qld	116
	P.I.Forster PIF12688 & P.Machin	Sundown National Park, *c.* 45 km SW of Stanthorpe, Qld	87

detected in the present study is a new cytotype for the genus in Australia. Previously Tindale & Roy (2002) reported a diploid cytotype (*n* = *c.* 29; 2x), and the present results indicate that three polyploid series (2x, 3x and 4x) occur in the species.

Some Australian collections of *Pellaea* have been considered to be of hybrid origin, this opinion being based on comparative frond morphology (Bostock 1998 & pers. obs.). Previously two triploid species of *Pellaea*, from sections other than sect. *Platyloma*, have been reported to be of hybrid origin (Manton & Sledge 1954; Tryon & Britton 1958).

Morphologically *P. calidirupium* in Australia has the appearance of an intermediate between *P. falcata* and *P. paradoxa*, both of which occur sympatrically with *P. calidirupium* in some northern parts of its range. Aborted spores indicative of hybrid origin have not been recorded for *P. calidirupium*, at least in Australia. However, Brownsey & Lovis (*op. cit.*) noted that the New Zealand distribution of *P. rotundifolia* is contiguous with *P. calidirupium* in some places, and they mention, without further discussion, that 'in some areas, hybrids may be found'. Further investigation is necessary to determine whether the triploid cytotype of *P. calidirupium* is sterile or is able to reproduce by apomixis.

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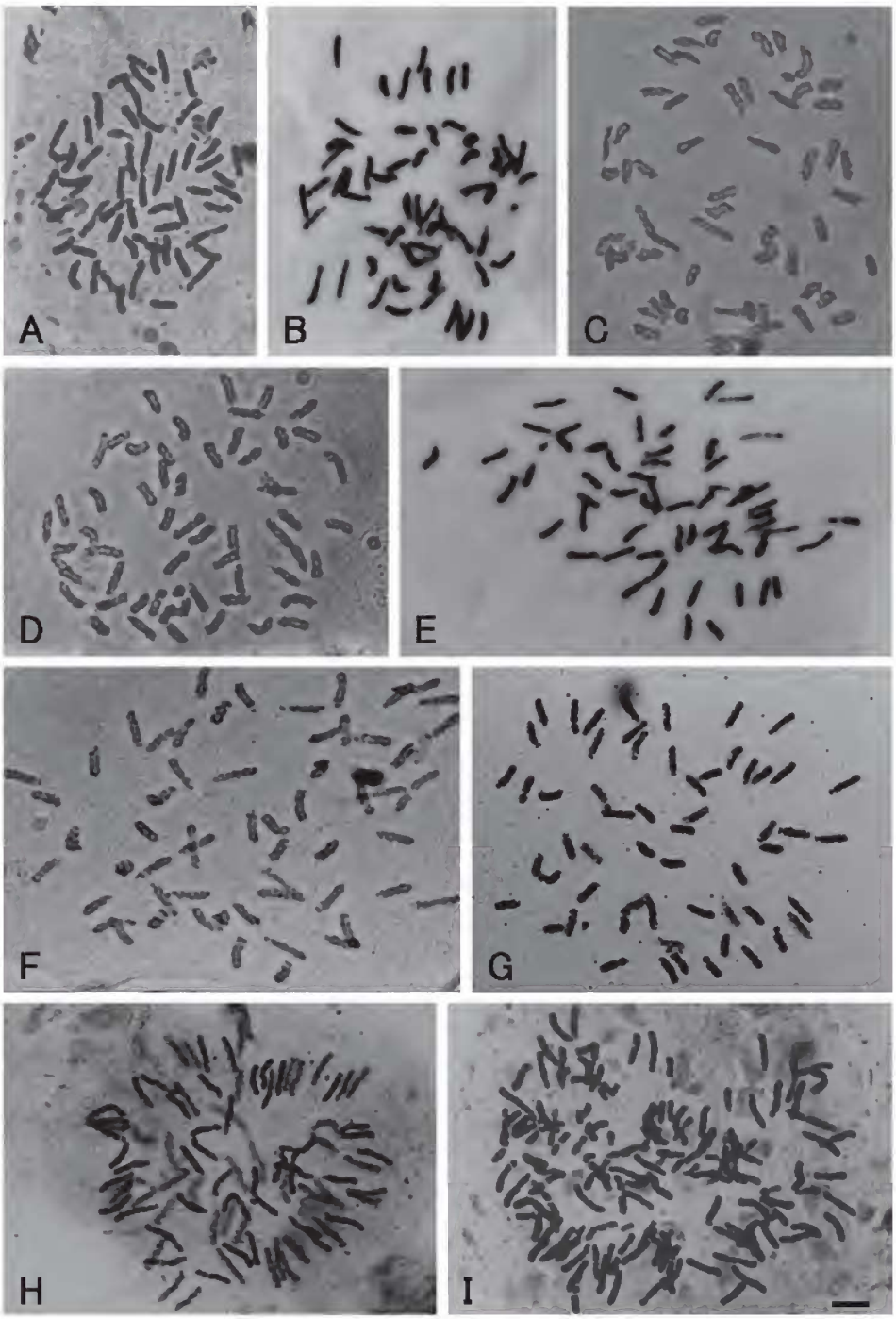

Fig. 1. Chromosomes at mitotic metaphase in nine Australian populations of *Pellaea*. A. *P. falcata* (*Bostock 358*; $2n = 58$). B. *P. falcata* (*Bruhl s. n.*; $2n = 58$). C. *P. falcata* (*Bostock 2005 & Kokubugata*; $2n = 58$). D. *P. nana* (*Bostock 794A et al.*; $2n = 58$). E. *P. nana* (*Bostock 2001 & Kokubugata*; $2n = 58$). F. *P. paradoxa* (*Bostock 2002 & Kokubugata*; $2n = 58$). G. *P. paradoxa* (*Bostock 2002 & Kokubugata*; $2n = 58$). H. *P. calidirupium* (*Forster PIF11602 et al.*; $2n = 116$). I. *P. calidirupium (Forster PIF12688 & Machin*; $2n = 87$). Bar represents 10 µm.

References

Benham, D.M. & Schaack, C.G. (1988). Adiantaceae. In A.Love (ed.), 'Chromosome number reports XCIX'. *Taxon* 37: 396–399.

Bostock, P.D. (1998). *Pellaea*. In P.M. McCarthy (ed.), *Flora of Australia* 48: 266–269. ABRS/CSIRO Publishing: Melbourne.

Britton, D.M. (1953). Chromosome studies on ferns. *American Journal of Botany* 40: 575–583.

Brownsey, P.J. & Lovis, J.D. (1990). *Pellaea calidirupium* – a new species from New Zealand. *New Zealand Journal of Botany* 28: 197–205.

Brownlie, G. (1954). Introductory note to cytotaxonomic studies of New Zealand ferns. *Transactions of the Royal Society of New Zealand* 82: 665–666.

—— (1957). Cytotaxonomic studies in New Zealand Pteridaceae. *New Phytologist* 56: 207–209.

—— (1961). Additional chromosome numbers in New Zealand Pteridaceae. *Transactions of the Royal Society of New Zealand (Botany)* 1: 1–4.

Garrett, M. (1992). Pteridophytes of north-east Tasmania. *Tasforests* 4: 57–68.

—— (1995). Distribution and ecology of ferns on dry outcrops in Tasmania, with special reference to Fingal Tier. *Tasforests* 7: 77–92.

Gastony, G.J. (1990). Electrophoretic evidence for allotetraploidy with segregating heterozygosity in South African *Pellaea rufa* A.F.Tryon (Adiantaceae). *Annals of the Missouri Botanical Garden* 77: 306–313.

Kato, M., Nakato, N., Cheng, N.-X. & Iwatsuki, K. (1992). Cytotaxonomic study of ferns of Yunnan, southwestern China. *Botanical Magazine (Tokyo)* 105: 105–124.

Knobloch, I.W. & Britton, D.M. (1963). The chromosome number and possible ancestry of *Pellaea wrightiana*. *American Journal of Botany* 50: 52–55.

Lewis, W.H. (1979). Polyploidy in species population. In W.H.Lewis (ed.), *Polyploidy*, pp. 102–114. Plenum Press: New York.

Lin, S.-J., Iwatsuki, K. & Kato, M. (1996). Cytotaxonomic study of ferns from China I. Species of Yunnan. *Journal of Japanese Botany* 71: 214–222.

Lovis, J.D. (1977). Evolutionary patterns and processes in ferns. *Advances in Botanical Research* 4: 229–415.

Manickam, V.S. & Irudayaraj, V. (1988). *Cytology of Ferns of the Western Ghats (South India)*. Today & Tomorrow's Printers & Publishers: New Delhi.

Manton, I. & Sledge, W.A. (1954). Observations on the cytology and taxonomy of the Pteridophyte flora of Ceylon. *Philosophical Transactions of the Royal Society of London* 238: 127–185.

Tindale M. D. (1972). Pteridophyta. In N.C.W. Beadle, O.D. Evans, R.C. Carolin (eds.) *Flora of the Sydney Region 2nd ed.*, pp. 36–94. Reed: Sydney.

Tindale M.D. & Roy, S.K. (2002). A cytotaxonomic survery of the Pteridophyta of Australia. *Australian Systematic Botany* 15: 839–937.

Tryon, A.F. (1968). Comparisons of sexual and apogamous races in the fern genus *Pellaea*. *Evolution* 12: 137–145.

—— (1972). Spores, chromosomes and relations of the fern *Pellaea atropurpurea*. *Rhodora* 74: 220–241.

Tryon, A.F. & Britton, D.M. (1958). Cytotaxonomic studies on the fern genus *Pellaea*. *Evolution* 12: 137–145.

Tryon, R.M. & Tryon, A.F. (1982). *Ferns and Allied Plants with Special Reference to Tropical America*. Springer–Verlag: New York.

Tryon, R.M., Tryon, A.F. & Kramer, K.U. (1990). Genus *Pellaea*. In K.U. Kramer & P.S. Green (eds.), *The Families and Genera of Vascular Plants I. Pteridophytes and Gymnosperms*, pp. 243–244. Springer–Verlag: New York.